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THE CRITICAL POINTS OF ALLOYS OF IRON AND COBALT DURING RAPID HEATING

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Translation of "Kriticheskiye tochki splavov zheleza s kobal'tom pri bystrom, nagreve", Metallofizika, No. 27, 1970, pp 84-87

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16. Abstract

The influence of the rate of heating on the position of the critical points of iron-cobalt alloys was studied.

For an alloy with 15% Co by weight, for which under ordinary conditions of heating the points of phase conversion and magnetic randomization (the Curie point) coincide, it was possible to show that for high rates of heating, a separation with respect to temperature occurs which clearly confirms the fact of the shift in the critical points of phase conversion.

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The study of phase conversions under conditions of rapid heating is associated with definite procedural difficulties, the chief of which must be considered to be the achievement of reliable recording of the phase conversion temperature. For this reason, there are in the literature extremely little experimental data concerning the influence of the rate of heating on the location of instrumentally observed critical points in solid solutions based on iron. The study of the systems iron-chromium and iron-silicon was described in [1] did not make it possible to detect an elevation of the critical points when the rate of heating was increased to 2000°/sec. The reason for this is apparently that the expected effect of "overheating" a critical point lies within the limits of precise temperature measurements.

When the rate of heating is increased above 2000°/sec, the error rarely increased due to the developing drift of the recording loop-thermocouple [2]. Taking this error into account by correcting the temperature with respect to the Curie point of ferrite made it possible for the first time to detect in pure iron the elevation which the critical point undergoes when the rate of heating is increased to 15000°/sec. Failure to take this error into account when measuring temperatures has caused a substantial distortion in experimental results [3] and, consequently, has led to an incorrect interpretation of the $\alpha \rightarrow \gamma$ -conversion mechanism in iron and steel, since the presence or absence of "overheating" of the instrumental critical point was associated with the fluctuation (nucleation and growth) or shift (martinsite) mechanisms of phase recrystallization [4-6]. In the present paper we wish to emphasize that data concerning the temperature dependence of critical points on the rate of heating is obviously unsatisfactory as a means of examining the mechanism of phase conversion, especially since the "stabilization" of a critical point may be only apparent and may

*Numbers in margin indicate pagination of foreign text.

cause definite procedural neglect. In order to prove this thesis, we have used the method of correcting temperature with respect to the Curie point. It is well known that during phase conversions of the second kind of heat of conversion is practically zero and the kinetics of such conversions does not depend on the rate of heat (the spin randomization in iron is effected after 10^{-16} sec). Yet the $\alpha \rightarrow \gamma$ -conversion (phase conversion of the first kind) depends on the amount of heat conducted to the metal, i.e., on the rate of heating. Thus, rapid heating of the appropriately chosen system to which the temperatures of the phase conversions of the first and second kind are arbitrarily close makes it possible to detect the presence or absence of "overheating" of the critical point relative to the Curie point which does not change with respect to temperature. /85

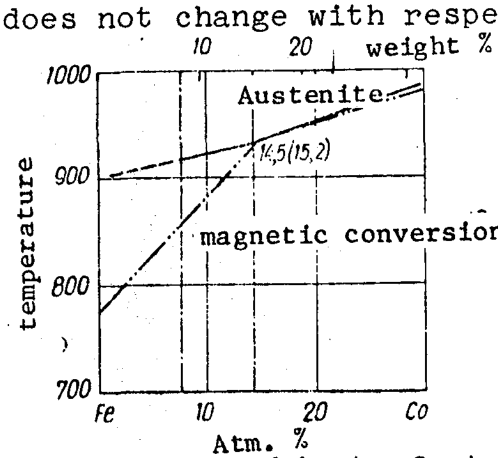

Figure 1. A part of the Fe-Co diagram [7] coated with alloy compounds.

The iron-cobalt system was selected as an object of study. In this system, the region of the homogeneous solid solution is characteristics for iron within a broad interval of cobalt concentrations [7].

Of decisive significance in the choice was the fact that here in proportion to the increase in the cobalt content there is a narrowing of the temperature interval between the Curie point and the $\alpha \rightarrow \gamma$ -conversion, and for 15.2% Co by weight, the temperatures of both conversions coincide (Figure 1.).

In the present work, we studied alloys with 8 and 15% of Co by weight. The Curie points are respectively at 850° and 910° C.

The alloys were smelted by the two-stage remelting method in a high-frequency oven, using bottom pouring into a copper ingot mold. The smelting was performed in purified argon with preliminary vacuum purification of the charge. The charge material for the alloys consisted of mark V-3 iron and 99.9% pure electrolytic cobalt.

To eliminate the coarse-grained quality of the cast alloys, which makes it impossible to forge them, the ingots were repeatedly subjected to cold plastic deformation and subsequent recrystallizational annealing. Only after this preliminary treatment was it possible to forge the alloys at 900 °C to a diameter of 6 mm. Samples for study were obtained by drawing down to a diameter of 1.2 mm. The final annealing of the samples as well as the homogenizing annealing of the ingots was carried out in argon at 1100 °C, using as getter titanium-zirconium (50%-50%) shavings. The samples were heated on an installation for comprenensive study of phase conversions during rapid heating [8]. The samples with operating part of length 100 mm were heated in the clamps of a lever dilato- /86
meter at rates from 20 to 10^4 degrees/sec by direct passage of a high-frequency current (2500 Hz).

Processing the oscillograms of the heating and the data from the thermal and dilatometric curves, taking into account the correction of the conversion temperature by means of the Curie point, have made it possible to establish that in the alloy with 8% Co by weight some elevation in the instrumentally determined critical point occurs during an increase in the rate of heating (Figure 2a).

The critical point was recorded as the origin of the $\alpha \to \gamma$ -conversion with respect to compression on the dilatometric curve. Elevation of the critical point of the phase conversion could be determined very clearly and convincingly on the alloy with 15% Co by weight. In this case, when the rates of heating were more than $5 \cdot 10^2$ degrees/sec, separation of the magnetic (Curie point) and the phase conversions occurred. During the increase in the rate of heating, the Curie point maintained its position, whereas the point

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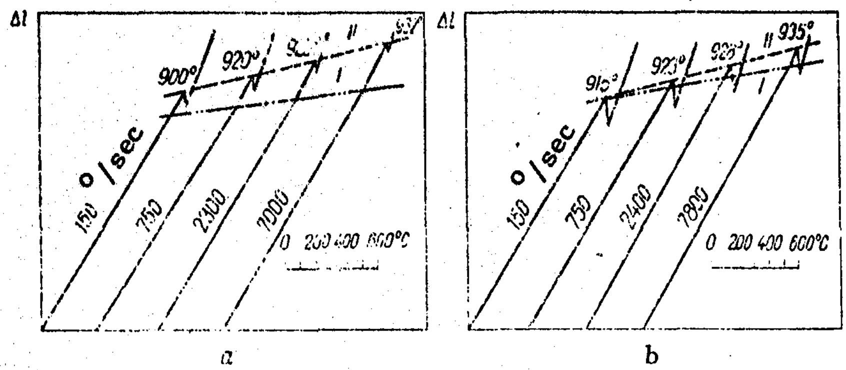

Figure 2. The dilatometric curves of alloys of iron with cobalt for different rates of heating: a) 8% Co by weight; b) 15% Co by weight; (I: The Curie point; II: the $\alpha \rightarrow \gamma$ -conversion).

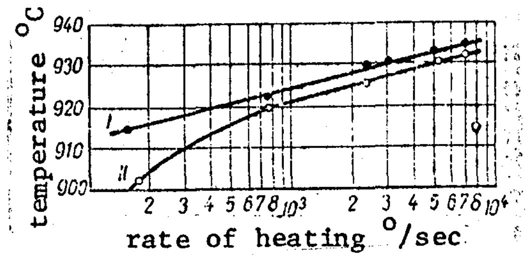

Figure 3. The value of the critical points of iron-cobalt alloys as a function of the rate of heating.
I: 15% by weight;
II: 8% by weight.

of phase conversion continuously shifted in the direction of the increased temperatures. This effect is observed in Figure 2b where the dilatometric curves from the samples heated at different rates are replotted as functions of the temperature. The apparent elevation of the temperature of the Curie point is connected with the fact that when the rate of heating a wire sample is increased, an increase in the effective length of its warming up occurs due to the decreased influence of the heat-conducting clamps of the dilatometer.

The results of the study of the influence of the rate of heating on the temperature of the $\alpha \rightarrow \gamma$ -conversion for both alloys are shown in Figure 3 from which it is evident that for rates of heating up to 10^4 degrees/sec the temperatures of formation of austenite for both alloys are shifted into the region of elevated temperatures and for rates of heating within the limits of up to 10^4 degrees/sec, they may reach 20 to 30°.

Conclusions. The influence of the rate of heating on the position of the critical points of iron-cobalt alloys was studied. It is shown that when an alloy with 8% Co by weight is heated at the rate of 7000°/sec, a shift in the temperature of phase conversion of almost 30° occurs. When an alloy with 15% Co by weight is heated at the same rate, the conversion temperature is shifted by approximately 20°. For an alloy with 15% Co by weight, for which under ordinary conditions of heating the points of phase conversion and magnetic randomization (The Curie point) coincide, it was possible to show that for high rates of heating, a separation with respect to temperature occurs which clearly confirms the fact of the shift in the critical points of phase conversion.

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